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Health Building Note 6 Supplement 1

Accommodation for magnetic resonance imaging

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Accommodation for magnetic resonance imaging

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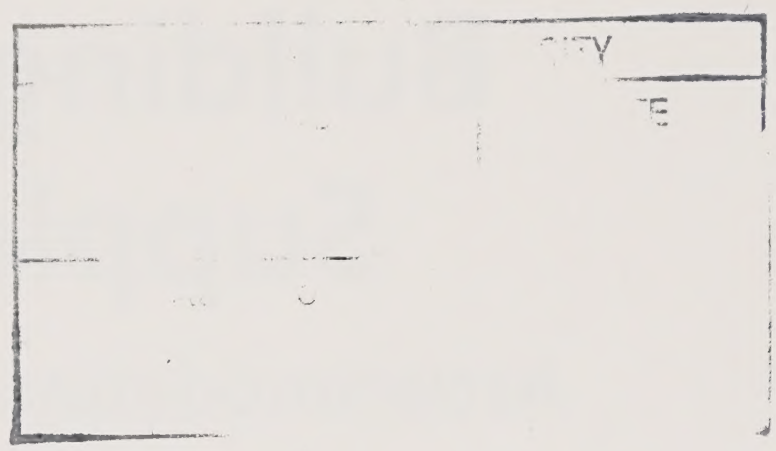

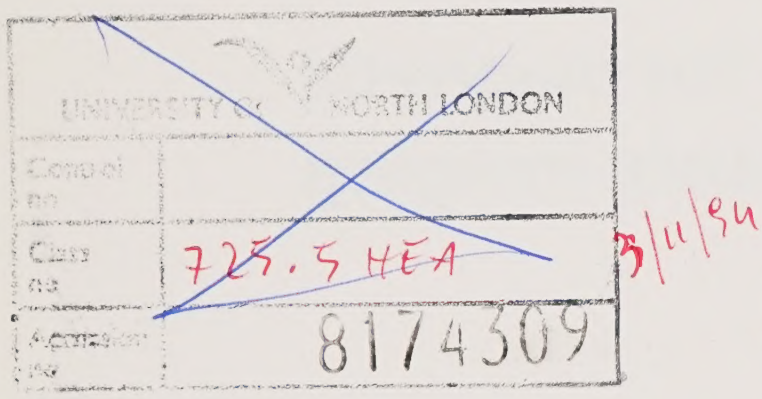

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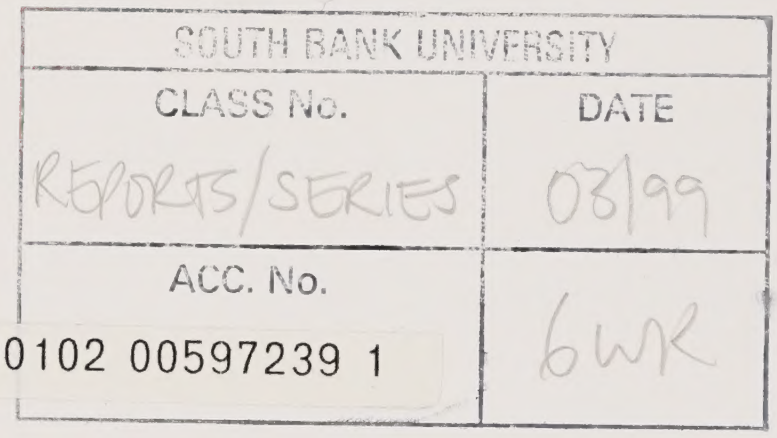

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About this publication

The Health Building Note series is intended to give advice on the briefing and design implications of Departmental policies.

These notes are prepared in consultation with representatives of the National Health Service and appropriate professional bodies. They are aimed at multidisciplinary teams engaged in:

a. designing new buildings;

b. adapting or extending existing buildings.

Throughout the series, particular attention is paid to the relationship between the design of a given department and its subsequent management as these factors have important implications for capital and running costs. The intention is to give informed guidance on which to base design decisions.

Health Building Note 6 – Supplement 1

Supplement 1 provides planning and design guidance for magnetic resonance imaging (MRI) suites against a background of rapid change. MRI scanners are getting smaller, lighter and portable models are appearing on the market. It complements the guidance contained in Health Building Note (HBN) 6 – 'Radiology department', published in 1992.

The MRI suite is assumed to be an integral part of the radiology department but, where this is not so, additional accommodation may be required and these options are described.

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1.0 Scope of Supplement 1 to Health Building Note 6

Introduction

1.1 Health Building Note (HBN) 6, Supplement 1, is a guide to the planning and design of magnetic resonance imaging (MRI) suites within a radiology department.

1.2 It is a Supplement to HBN 6, 'Radiology department', 1992. HBN 6 provides planning and design guidance for general radiology departments. The Supplement should be read in conjunction with HBN 6.

1.3 Since the early 1980s, provision of MRI services in the National Health Service (NHS) has changed significantly. Initially, MRI was a highly-specialised clinical tool for teaching hospitals with specialist centres. It is now an important diagnostic tool which may increasingly be used by radiology departments in acute general hospitals. Improved access for NHS patients to MRI has resulted in earlier diagnosis of many conditions. MRI has replaced other, often more expensive, less effective and invasive tests.

1.4 The recommendations relevant to health buildings of the Department of Health Medical Devices Directorate's 'Guidelines for magnetic resonance diagnostic equipment in clinical use with particular reference to safety', 1993, (hereafter referred to as MDD guidelines and available through HMSO) have been recognised in the preparation of this Supplement. However, project teams are advised to consult and to take account of the more detailed and additional guidance of the MDD guidelines. The MDD guidelines incorporate the National Radiological Protection Board's 'Statement on clinical magnetic resonance diagnostic procedures', 1991.

Range of provision

Inclusions

1.5 This Supplement describes an MRI suite with a scanner of defined field strength (see paragraph 2.8) within a radiology department (see paragraph 2.36).

Exclusions

1.6 The Supplement does not deal with:

a. scanners of high-field strength – over 1.5 Tesla (see paragraph 2.8);

b. a mobile suite;

c. magnetic resonance spectroscopy (MRS). MRS is excluded because:

   (i) an MRI scanner with a high-field strength magnet is required;

   (ii) use of MRS for clinical purposes has not yet developed sufficiently to justify widespread introduction in the NHS.

2.0 General service considerations

Introduction

2.1 MRI scanners were first installed in UK hospitals in 1980. In 1981 there were few centres in the world concerned with clinical applications and the development of MRI and most were in the UK.

2.2 MRI is a technique which combines a powerful magnet, magnetic fields, radio signals, and a sophisticated computer to produce high quality images of chosen parts of the body. The images are similar to those produced by an X-ray machine: they can be viewed on a TV monitor and produced as hard copy like X-ray films. MRI images, however, include soft-tissue information that is not available on a plain X-ray.

2.3 MRI is:

a. a non-invasive or minimally-invasive technique;

b. completely pain-free when non-invasive (although the procedure may cause claustrophobia);

c. safe (provided safety and control of access measures are followed, see paragraphs 2.16, 2.17, 2.19 and 2.42) and has no known side-effects. Patients are not exposed to ionising radiation.

2.4 The remainder of this chapter is divided into two main parts. The first part deals with the 'Technical considerations' of MRI and the second part examines 'Clinical issues'.

TECHNICAL CONSIDERATIONS

2.5 Magnetic resonance imaging systems and equipment are considered in relation to the principal components identified in paragraph 2.2, that is:

a. a magnet;

b. radio signals;

c. a computer.

A magnet

Magnetic field strength

2.6 The size of an MRI scanner is expressed in terms of the field strength of its magnet.

2.7 The magnetic field strength of magnets used in MRI scanners is measured in Tesla. One Tesla is equal to 10,000 Gauss. The magnetic field on the surface of the earth is approximately 0.6 Gauss. By common definition, there are three main categories of MRI scanners:

a. low-field strength (less than 0.5 Tesla);

b. mid-field strength (0.5 to 1.5 Tesla);

c. high-field strength (greater than 1.5 Tesla).

2.8 This Supplement is concerned mainly with the planning and design of accommodation for a mid-field strength MRI scanner although most of the guidance is relevant to an MRI suite where a low-field strength MRI scanner is to be installed. It does not deal with the accommodation needs of a high-field strength MRI scanner as these are found typically in university and teaching hospitals and other specialised units.

Types of magnet

2.9 Three main types of magnet are used for MRI, as follows:

a. cryogenic superconducting electromagnets. The coils of these magnets operate at or near absolute zero temperature (–273°C), producing low-field, mid-field and high-field strengths. Certain types are available which recycle the cryogen;

b. permanent magnets. These magnets consist of an assembly of magnetised iron alloy briquettes and do not require either electricity or cooling to operate. They produce field strengths of up to 0.3 Tesla and can weigh many tonnes;

c. resistive magnets, but generally up to 0.3 T and very uncommon.

2.10 It is essential that advice is sought from MRI and structural engineering specialists when consideration is being given to the selection of the magnet. The types of magnet outlined above have planning and design implications which differ significantly from each other.

2.11 This Supplement concentrates on accommodation required for an MRI scanner with a cryogenic superconducting electromagnet.

Magnetic shielding systems

2.12 It may be necessary to shield magnets in an MRI scanner in order to contain the "stray" magnetic field and to protect the magnetic field from stationary and non-stationary ferrous metals in the environment, for example structural steelwork, pipes, lifts and vehicles.

2.13 Three main approaches are used to shield the magnet in an MRI scanner, as follows:

a. self-shielding. This consists of large pieces of iron in the magnet design;

b. room-shielding. This consists of pieces of iron strategically placed on the walls and/or ceiling and floors of the scanner room;

c. active-shielding. This involves two sets of windings in a superconducting magnet which generate opposing magnetic fields.

Self-shielding and room-shielding are also referred to as passive-shielding.

2.14 It is essential that advice is sought from MRI and structural engineering specialists when consideration is being given to the selection of the magnetic-shielding system. Shielding systems outlined above have planning and design implications which differ significantly from each other. The weight which needs to be added to the overall weight of the MRI scanner room in respect of the magnetic shielding system is:

a. many tonnes for a passive shielded magnet;

b. not structurally significant for an actively shielded system.

2.15 This Supplement concentrates on accommodation required for an MRI scanner with an active-shielding system.

Safety and control of access

2.16 Project teams concerned with the planning and design of MRI suites must take account of the MDD guidelines.

2.17 The MDD guidelines stress and describe in detail the need to control access to MRI equipment. They recommend that:

- a responsible person should be appointed, and, "in order to cover all the necessary aspects of safety, each responsible person should be in full consultation with advisers who are appropriately designated professionals, having adequate training, knowledge and experience of diagnostic magnetic resonance equipment, its uses and associated requirements. The designated professional advisers should be in a position to cover adequately the necessary clinical engineering and scientific aspects of the safe clinical use of the magnetic resonance devices". It is recommended that the responsible person and the advisers should be appointed and available to be consulted by project teams well in advance of the installation of an MRI scanner;
- MRI equipment should be contained in a designated controlled area;
- the controlled area should be totally enclosed;
- the controlled area should be large enough "to contain the 0.5 mT (5 Gauss) magnetic field contour" of the magnet in the MRI scanner. Consideration must also be given to the extent of the 5 Gauss line vertically, that is, above the ceiling of the room underneath and below the floor of the room overhead;
- access to the controlled area should be provided by the minimum practical number of self-locking doors;
- only authorised personnel (defined in the MDD guidelines) should have free access to the controlled area. All other personnel must be accompanied or supervised at all times by an authorised person while in the controlled area. A warning message which must be clearly displayed at each entrance to the controlled area is specified in the MDD guidelines;
- in an emergency, access to the controlled area must be subject to the direct supervision of adequately trained and authorised personnel. It is very important to notify outside bodies, particularly the fire brigade, of the special environment of the controlled area.

2.18 Figure 1 indicates typical space required to contain the 5 Gauss magnetic field contour of a 1.5 Tesla magnet:

2.19 The enclosure of the controlled area should be coterminous with the MRI scanner room within which ferromagnetic and other objects are not permitted or would be damaged. As well as the personal items described in paragraph 2.42(c), objects not permitted also include such items as tools, gas cylinders, trolleys and ferromagnetic life-support systems or systems which contain ferromagnetic components.

Radio signals

Radio-frequency pulses

2.20 A transmitter coil is used to deliver radio-frequency (RF) pulses to the patient's body during the MRI procedure. A large coil which surrounds the body is used usually as a transmitter.

2.21 A receiver coil is used to receive the weak RF pulses returned by the part of the patient's body being imaged: this is known as the magnetic resonance (MR) signal. The transmitter coil can be used as a receiver coil for whole body images but, normally, a selection of receiver coils is provided with an MRI scanner which are designed to have a high sensitivity to, and to be placed close to, the part of the body being imaged. See Figure 2.

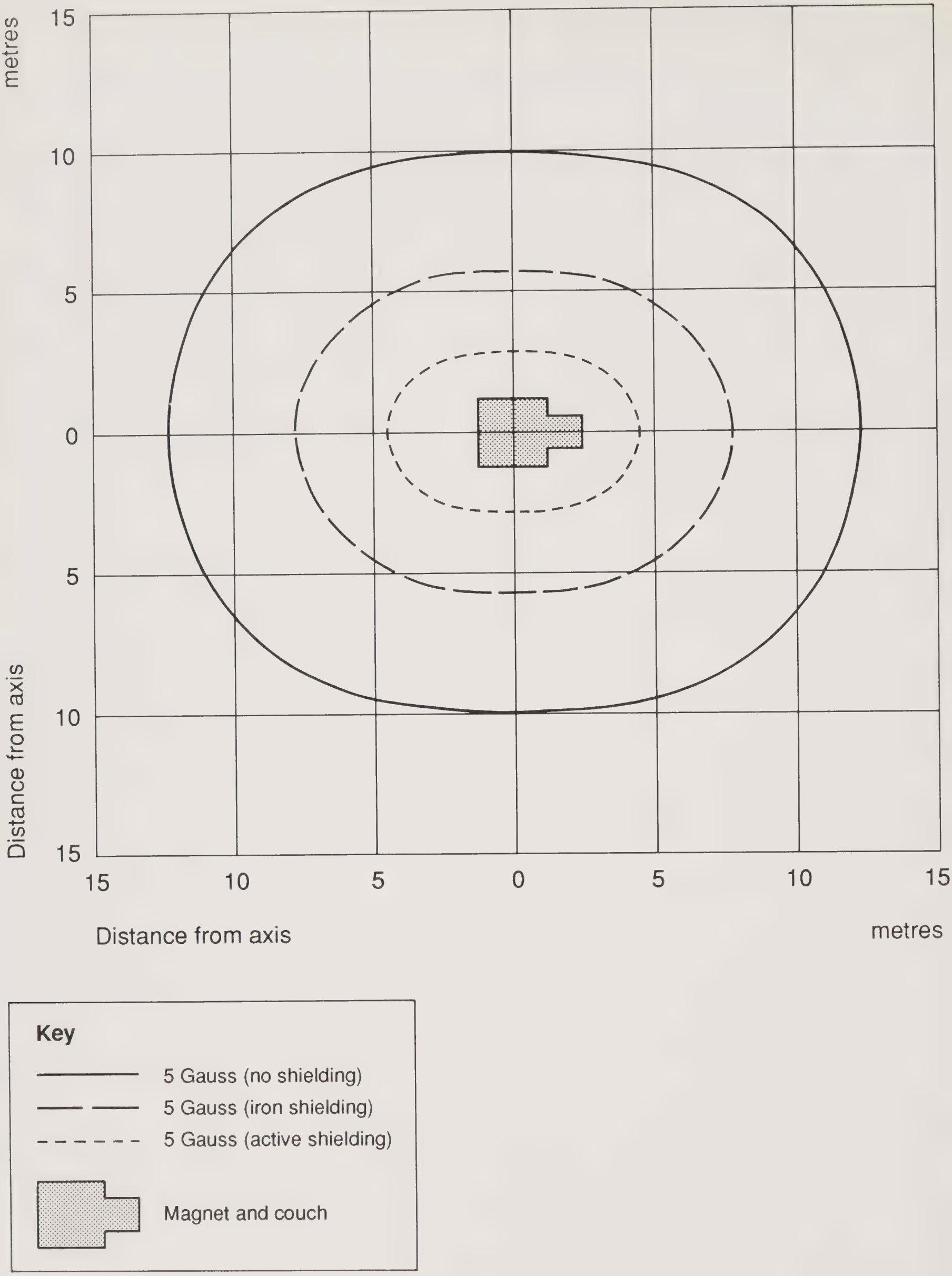


Figure 1 Typical Iso-Gauss lines for 1.5 Tesla magnet

Quadrature C-spine coil for optimal results in the cervical spine area in both sagittal and transverse directions.

Quadrature Volume Neck coil for high quality MR Angiography of the carotid arteries.

Dual TMJ coils on flexible supports for interleaved bilateral acquisition and kinematic studies.

Quadrature Knee coil. Split-coil design allows fast and easy positioning. Shown here used in combination with a circular coil for bilateral knee study.

Figure 2 Examples of receiver coils (courtesy Philips)

Radio-frequency shielding systems

2.22 It is necessary to shield MR signals and the receiver coil in an MRI scanner from contamination by extraneous signals which may be generated by a wide range of sources, including TV transmitters, commercial radio stations, two-way radios, paging systems and many types of electrical equipment, including computers.

2.23 RF-shielding is often provided by constructing an RF-shielded enclosure within the room containing the MRI scanner. Only a narrow gap needs to be left (for assembly purposes) between the RF-shielded enclosure and the "conventional" walls of the building. Various types of RF-shielded enclosures are available, including those which consist of:

- wooden panels with heavy copper foil bonded to one side (to provide the RF-shielding) and, for example, a finished wall surface bonded to the other side;
- heavy copper foil stretched over a lightweight wooden frame;
- stainless steel (non-magnetic) panels which provide the mechanical structure of the room;
- thick iron walls. This type of enclosure provides magnetic-shielding as well as RF-shielding.

2.24 It is essential that advice is sought from RF-shielding specialists when consideration is being given to the selection of the RF-shielding system. Some RF-shielding systems have significant planning and design implications.

2.25 Further information is provided about RF-shielding in Chapter 5, 'Engineering services', and in Appendix 1.

A computer

2.26 A computer is linked to the MRI scanner. The computer detects and analyses the MR signals, converts the digital data into an image of the area of the patient's body being scanned and displays the image on a visual display terminal (VDT).

2.27 The introduction of computer-based workstations has produced a facility for rapid manipulation of the large volumes of digital data generated by an MRI system. These facilities enable complex structures of the body to be viewed from any direction in any plane. Such devices can be used as simulators to permit surgical and radiotherapy planning.

2.28 The computer is controlled from an operating console. Films of selected images are produced by a hard copy unit which receives instructions from the operating console. VDTs with keyboards, linked to the operating console but in a separate room, provide an additional and alternative location where MRI staff can manipulate the digital data, view, study and/or report on the image, and order films of selected images.

CLINICAL ISSUES

Patients and their requirements

2.29 Patients attend an MRI suite as part of hospital radiology services. The condition of patients attending an MRI suite corresponds to the condition of patients attending other parts of the radiology department. Patients tend to follow the same pattern of referrals as for specialised procedures in the radiology department.

2.30 Patients who attend an MRI suite may:

a. be out-patients or in-patients. The majority of referrals will be out-patients but some in-patients will attend;

b. be adults or children;

c. arrive on a bed, on a trolley, in a wheelchair or on foot;

d. be accompanied by an escort;

e. need to change;

f. need to be sedated;

g. need general anaesthesia and to recover from anaesthesia;

h. be attached to monitors;

j. be severely ill and attached to life-support equipment and could need resuscitation;

k. suffer from learning difficulties.

2.31 MRI is a highly specialised and technical procedure and patients may be nervous. Designers should not simply provide spaces which satisfy functional requirements: they should aim to create an aesthetically attractive and interesting environment which inspires confidence in the service being offered and helps to relieve anxiety.

Workload

2.32 The number of patients per annum that can be accommodated by one MRI scanner is affected by:

a. the types of examination carried out. Some examinations take only a few minutes whereas others take longer;

b. the total examination time available. This is determined by the lengths of the working day, the working week and the working year. MRI suites tend to operate extended working hours to maximise on the capital investment;

c. the availability of radiology, radiography and support staff to operate the MRI scanner and run the MRI suite to maximum effect during the examination time available;

d. the magnetic field-strength of the MRI scanner;

e. the facilities for induction of, and recovery from, general anaesthesia.

2.33 MRI technology continues to develop rapidly, with consequent improvement in the range of, and time required for, examinations.

2.34 Typically, the number of examinations per hour that currently can be accommodated by a mid-field strength MRI scanner are:

a. two to three single-area examinations, for example examinations of the brain, the spine or the knee;

b. one to two more complex examinations.

2.35 Examinations carried out using a low-field strength MRI scanner tend to take longer than examinations carried out using a mid-field strength MRI scanner.

Location of MRI suite

2.36 The MRI suite should be integral with a new radiology department or integrated as closely as possible with an existing radiology department.

2.37 Most of the patients who attend the MRI suite will be out-patients and not likely to visit any other department on the same day. For these patients, it is helpful if the MRI suite is close to the main entrance to the hospital.

2.38 For in-patients who attend the MRI suite, there should be easy access from the wards and for a patient trolley.

2.39 HBN 6 describes the provision of ultrasound, computed tomography (CT) and nuclear medicine imaging suites within the radiology department and assumes that shared-use can be made of spaces such as the reception/ appointments area and the patients' main waiting area. This Supplement deals with the MRI suite similar to the way HBN 6 deals with, for example, the CT suite. In connection with the CT suite, HBN 6 states, "CT should be regarded as an integral part of the radiology department when considering service and planning issues".

2.40 The MRI suite may operate during periods when other parts of the radiology department are not in use. Project teams should ensure that access for patients and use of shared spaces are satisfactory at these times.

Clinical management of patients

2.41 Clinical management of patients within the MRI suite can be described under four main headings, as follows:

a. pre-examination questioning;

b. preparation procedures;

c. MRI examination;

d. post-examination procedures.

Pre-examination questioning

2.42 Questioning of patients prior to an MRI examination is essential in order:

a. to explain procedures, with a view to:

(i) informing them about what happens during the examination;

(ii) seeking their co-operation. For example, it is important that patients keep still during the MRI scanning process;

(iii) relieving anxiety;

b. to ascertain and discuss potential hazards, particularly with reference to women of reproductive age;

c. to identify ferromagnetic and other objects which are not permitted, or would be damaged, in the MRI scanner room. For example:

(i) pacemakers and metallic implants. All patients who wear pacemakers and some who have metallic implants should not be examined in an MRI scanner;

(ii) loose ferromagnetic objects which may be carried by a person. In approaching a magnet, the magnetic pull can increase significantly in a short distance, causing an object to leap out of the hand before there is time to react. As the uncontrolled object moves closer to the magnet, it accelerates at an ever-increasing rate until it hits someone, some other object and/or the magnet at great force. Such instances may result in people being injured and/or the image quality of the MRI scanner being seriously degraded;

(iii) dental plates, false limbs, surgical corsets and jewellery. Personal items such as these may distort the image quality;

(iv) magnetic media, credit cards, watches, etc.

2.43 Patients may be asked to complete a standard questionnaire at home in order to assist pre-examination questioning. On occasions, it may be necessary for patients to be X-rayed in order to screen for metal clips or metallic deposits.

2.44 Pre-examination questioning should take place in a quiet room outside the controlled area.

Preparation procedures

2.45 The need for preparation procedures will be determined partly by local policies and partly by the condition of patients.

2.46 Patients will need to deposit ferromagnetic objects, items such as credit cards, and other small items of personal belongings, prior to entering the scanner room. Secure storage facilities should be provided just outside the controlled area.

2.47 Local policy may dictate that patients should undress and wear a gown for the examination – in which case changing and clothes storage facilities will be required.

2.48 Patients who are anxious may need to be sedated. Young children, people with learning difficulties and patients who are severely ill or injured may need to be sedated or require general anaesthesia in order to relieve anxiety and/or ensure that they do not move during the course of the MRI examination. Suitable facilities should be provided for the administration of sedation and the induction of anaesthesia.

MRI examination

2.49 All patients will need to be observed during the MRI examination.

2.50 Repeated exposures should be avoided by staff as a sensible precaution against possible unknown hazards. It is not advisable, therefore, for staff from the MRI suite to remain in the MRI scanner room when examinations are being carried out. However, staff from a ward, or a patient's escort, may do so, if necessary, as they are likely to be subject to only a single exposure.

2.51 MRI staff should be able to observe patients through an observation window from an adjacent space. MRI staff should also have contact with conscious patients by means of a two-way intercom and/or closed-circuit television (CCTV).

2.52 Patients who are examined while sedated will need ECG and pulse oximetry monitoring as a minimum. Patients who are anaesthetised will need ECG, blood pressure, pulse oximetry and capnography as a minimum. Patients who are unconscious or critically ill may need airway protection and controlled ventilation as well as monitoring. All equipment used for procedures in the MRI scanner room must be MRI compatible (see paragraph 2.19 and the MDD guidelines).

2.53 Some monitoring and anaesthetic equipment may be kept in the control room and connected to the patient through waveguides.

Post-examination procedures

2.54 After MRI examination, patients:

a. may need to recover from sedation or general anaesthesia;

b. will need to regain their personal possessions and, if necessary, to change;

c. will need to be advised about what to do next. For example, they may:

   (i) be referred to the reception desk to make an appointment and leave the department;

   (ii) be asked to wait to discuss examination results with a doctor, prior to making an appointment and leaving.

2.55 Patients and escorts may be distressed and need to be counselled. A counselling room should be provided which is comfortable and domestically furnished.

Anaesthetic services

2.56 General anaesthesia cannot be conducted in an MRI scanner on an *ad hoc* basis. Almost all units will require, on occasion, to deal with patients who either require general anaesthesia or who are sufficiently ill to need support equivalent to general anaesthesia. Suitable facilities should therefore be provided for this purpose.

2.57 Sedation and anaesthesia in 'Radiology', July 1992, contains the recommendations of the Joint Working Party of the Royal College of Radiologists and the Royal College of Anaesthetists.

2.58 If patients are to be monitored remotely, waveguides should be provided between the scanner and control rooms to accommodate monitoring links.

Consultant anaesthetist

2.59 Project teams should consult an anaesthetist at an early stage of the project in addition to the professionals identified in the MDD guidelines.

2.60 A consultant anaesthetist should be nominated to be responsible for patient care in the MRI suite.

Anti-static flooring

2.61 The 'Report of a Working Party to Review the Anti-static Requirements for Anaesthetising Areas' (1990), recommends that project teams should consider, in consultation with the Department of Anaesthesia, whether they wish to use flammable anaesthetic agents. If the trend to dispense with these agents is followed, no anti-static provision will be necessary. However, in view of the historical position on the subject, suitable warning notices must be displayed.

3.0 Functional requirements

Introduction

3.1 This chapter describes the functional requirements and design implications for each space in an MRI suite.

3.2 Activities, equipment, environmental conditions, wall, floor and ceiling finishes relative to each space are detailed on the Activity Data Sheets listed in Chapter 7 of this Supplement and in HBN 6 (Chapter 7).

Patient flow

3.3 The common sequence of patient flow described in HBN 6 (paragraph 3.2) is relevant to this Supplement. Additional key events in the sequence are:

a. pre-examination questioning (see paragraph 2.42);

b. post-examination discussion and/or counselling, if necessary (see paragraphs 2.54c(ii) and 2.55).

Reception/office

3.4 HBN 6 states that the reception/appointments area "should be designed to serve the whole department". The "whole department" should be considered to include the MRI suite, where appropriate.

3.5 It may be impractical for the main reception/ appointments area to serve the MRI suite, for example, due to the distance between the two locations. In such cases, a reception/office should be provided in the MRI suite.

3.6 The reception/office has two main functions: reception of patients and escorts, and administration and communication centre of the suite.

3.7 The reception counter should be located and designed so that:

a. there is easy access from the entrance to the MRI suite;

b. it is obvious to patients and escorts when entering the MRI suite;

c. a seated receptionist can see:

   (i) all patients and escorts entering the suite and in the main waiting area;

   (ii) the bed/trolley/wheelchair waiting area;

d. there is access:

   (i) to the main waiting area;

   (ii) to the sub-waiting area.

3.8 A single-person reception counter will be adequate for the number of patients who will attend an MRI suite with one MRI scanner room.

3.9 At the reception counter, the receptionist will receive and register patients, book appointments at other clinics, supervise the main waiting area and direct patients to the sub-waiting area. Patients, escorts and staff must be able to talk and exchange information with ease. Discussions which require a greater level of privacy may be held in a patient preparation room or the counselling room. Space will be required at the reception counter for a visual display terminal (VDT) with a keyboard linked to the departmental computer and for a working supply of stationery and office accessories.

3.10 Office activities may include management of the patient appointments system, preparation of patient documentation, preparation and issue of reports on patients, liaison with other parts of the healthcare system, preparation of general reports and analysis of statistics. Provision of Type 5 and/or Type 6 office workstations (see HBN 18 – 'Office accommodation in health buildings') is appropriate. VDTs are required for word-processing and other computer-related activities. Consideration should be given to routing all telephone calls to and from the MRI suite through the reception/office.

3.11 Emergency call, Controlled Drugs cupboard, and other indicators, may terminate or be repeated in the reception/ office and be monitored by staff based there.

3.12 Staff in the reception/office will need to communicate with, and transfer documents to, staff in the control room, and vice-versa, for example, to indicate the arrival and the departure of patients. Provision of a hatch between the two rooms will facilitate these activities.

Main waiting area

3.13 A main waiting area should be provided in the MRI suite if it is impractical for MRI patients to use the patients' main waiting area serving the rest of the radiology department.

3.14 The main waiting area should have a comfortable and relaxing environment with domestic-type finishes and furnishings. Different types of seating may be appropriate, including chairs suitable for elderly people and children. The layout should be informal. There should be space for a patient in a wheelchair. Project teams may wish to consider the provision of low level background music and/or a TV/video system. These may help patients relax, alleviate the boredom

of essential waiting, particularly for children, and mask confidential discussions. A supply of current reading material should be available in a well-designed holder. Notices and other information should be displayed on wall-mounted panels.

3.15 The main waiting area should have direct access from the entrance to the MRI suite, be overseen by the reception counter of the reception/office and have easy access to the sub-waiting area.

Bed/trolley/wheelchair waiting area

3.16 A bed/trolley/wheelchair waiting area should be provided in the MRI suite if it is impractical for MRI patients to use the patients' bed/trolley/wheelchair waiting area serving the rest of the radiology department.

3.17 The bed/trolley/wheelchair waiting area should be separate from other waiting areas and provide space for patients on beds or trolleys to wait before being transferred to the MRI trolley for MRI examination. It may be decided that patients in wheelchairs should wait here rather than in the main waiting area. The space allowed should reflect which option is chosen. In this area, circulation space will be required for nurses or others attending the patient and for additional equipment which may be on trolleys. This area may be a recess off the relevant circulation space and should be observable from the reception counter of the reception/office. Curtaining should be provided for privacy when required.

Master index/report index/diagnostic index

3.18 Data storage provided for the "whole department" adjacent to, or forming part of, the reception/appointments area should be used for the storage of as much data as possible from the MRI suite. Storage facilities for data which needs to remain in the MRI suite are provided in the reception/office. VDTs in the MRI suite should be linked to the departmental computer system.

Counselling room

3.19 A counselling room should be provided in the MRI suite if it is impractical for MRI patients to use the counselling room serving the rest of the radiology department.

3.20 A counselling room is required where patients and escorts can be interviewed, counselled and comforted, in private as necessary. The counselling room may be used as an alternative to the patient preparation room for pre-examination questioning and is essential for some post-examination procedures.

3.21 The room should be comfortably furnished and include easy and upright chairs and an occasional table. A desk, with desk chair, should be provided to enable a member of staff to make notes while talking to a patient and/or escort. The counselling room may be used by visiting staff as an office when not required for use with patients and/or escorts.

3.22 The walls of the counselling room should be constructed so as to attenuate sound and provide an acceptable level of speech privacy. The room should be close to the patient preparation rooms and sub-waiting area, if provided, and easily accessible from the MRI scanner room.

Patient preparation room

3.23 Patient preparation rooms are required where a patient can, as necessary:

a. relax and wait with an escort before and after an MRI examination. During the examination the escort may remain in the patient preparation room, subject to availability, or be asked to wait in the main waiting area or patients' sub-waiting area, if provided;

b. undress and dress in privacy;

c. securely store clothing and small items of personal belongings;

d. hold confidential discussions, including pre-examination questioning, preparation procedures and some post-examination procedures. Auditory privacy should be provided as far as practicable;

e. use a patient-to-staff call system.

3.24 In the interests of maintaining a non-clinical environment as far as possible, each patient preparation room might include a domestic-style vanitory unit with one or more lockable compartments for the secure storage of a patient's belongings, a handwash basin, mirror, and cupboard for holding procedure gowns. Patient preparation rooms should not be cramped. Compartments should be provided with non-ferromagnetic keys which can be taken into the MRI scanner room. Each requires an easy chair for the patient and for an escort. One room should be capable of accommodating a person in a wheelchair. The provision of low-level background music should be considered.

3.25 Patient preparation rooms should be located close to the counselling room and have easy access from the main waiting area and to the MRI scanner room.

Patients' sub-waiting area

3.26 A sub-waiting area is required where a small number of patients and escorts can wait before, during and after an MRI examination, as appropriate. The sub-waiting area also

provides an alternative to waiting in a patient preparation room. Patients may be fully dressed, partially dressed or wearing only a procedure gown.

3.27 The sub-waiting area should be comfortably furnished with easy chairs and an occasional table and include a wall-mounted panel where information can be displayed. Project teams may wish to consider the provision of low level background music and/or a TV/video system instead of, or additional to, that which may be provided in the main waiting area and the patient preparation rooms. A soiled linen trolley for the disposal of used gowns may be parked here.

3.28 The sub-waiting area should be adjacent to the patient preparation rooms, close to the counselling room and have easy access from the main waiting area (or from the entrance to the MRI suite if a main waiting area is not provided there) and to the MRI scanner room.

Patients' WCs

3.29 WC facilities for patients should be provided close to the main waiting area and the sub-waiting area. At least one WC close to each area should have access for a wheelchair, space for assistance to be given, and grab rails.

Locker bay

3.30 A bank of small ("cube") lockers are required where staff, escorts and visitors who are entering the MRI scanner room can securely store items of personal belongings which should not be taken into that room (see paragraph 2.42.c). Staff who work in the MRI suite may also use the lockers for the secure storage of other items of personal belongings. The lockers should be provided with non-ferromagnetic keys which can be taken into the MRI scanner room. The bank of lockers should be accommodated in a locker bay located convenient for use by personnel entering the MRI scanner room.

MRI scanner room

3.31 The main and central piece of equipment in the MRI scanner room (see Figure 3) is the MRI scanner itself, consisting of the magnet and its enclosure and the patient couch. The type of scanner will determine certain planning and design requirements. A technical equipment room is required to accommodate equipment provided in support of the MRI scanner.

3.32 There are few, if any, spaces entered by conscious patients which have such a highly technical piece of equipment and environment as a scanner room. Modern MRI scanners in hospitals are tastefully designed but the scanner room can be a forbidding place for patients and great care should be taken with its interior design.

3.33 Project teams should consult specialist advisers, including radiology and anaesthetic staff, the responsible person, and manufacturers, as soon as possible in the planning process. Early consideration should be given to the type of:

a. magnet;

b. radio-frequency (RF) shielding;

c. magnetic shielding, if required.

3.34 The area and cost allowance associated with this Supplement permits a system to be installed which includes any type of:

a. magnet up to 1.5 Tesla;

b. radio-frequency (RF) shielding;

c. magnetic shielding, if required.

This statement is based on the state of technology and equipment available at the time this Supplement was prepared. It is anticipated that the rapid developments of MRI will reduce rather than increase the area and cost requirements of MRI equipment.

3.35 Workflow in a scanner room follows a typical sequence, as noted below:

a. the patient enters on foot or on an MRI trolley, attended by MRI staff, and may be accompanied by a nurse from the ward or an escort;

b. the patient mounts, or is transferred to, the scanner couch and is positioned for the examination by MRI staff;

c. MRI staff may select and position an appropriate separate receiver coil;

d. MRI staff leave the scanner room and the scan is carried out. The patient may need to be repositioned between scans. The nurse from the ward or the escort may remain in the scanner room for the period of the examination. The patient is in constant audio and visual contact with MRI staff;

e. after the examination, the patient dismounts, or is transferred to the MRI trolley from the scanner couch and moved to the sub-waiting area, patient preparation room or counselling room, as appropriate.

3.36 During an MRI examination, patients may be:

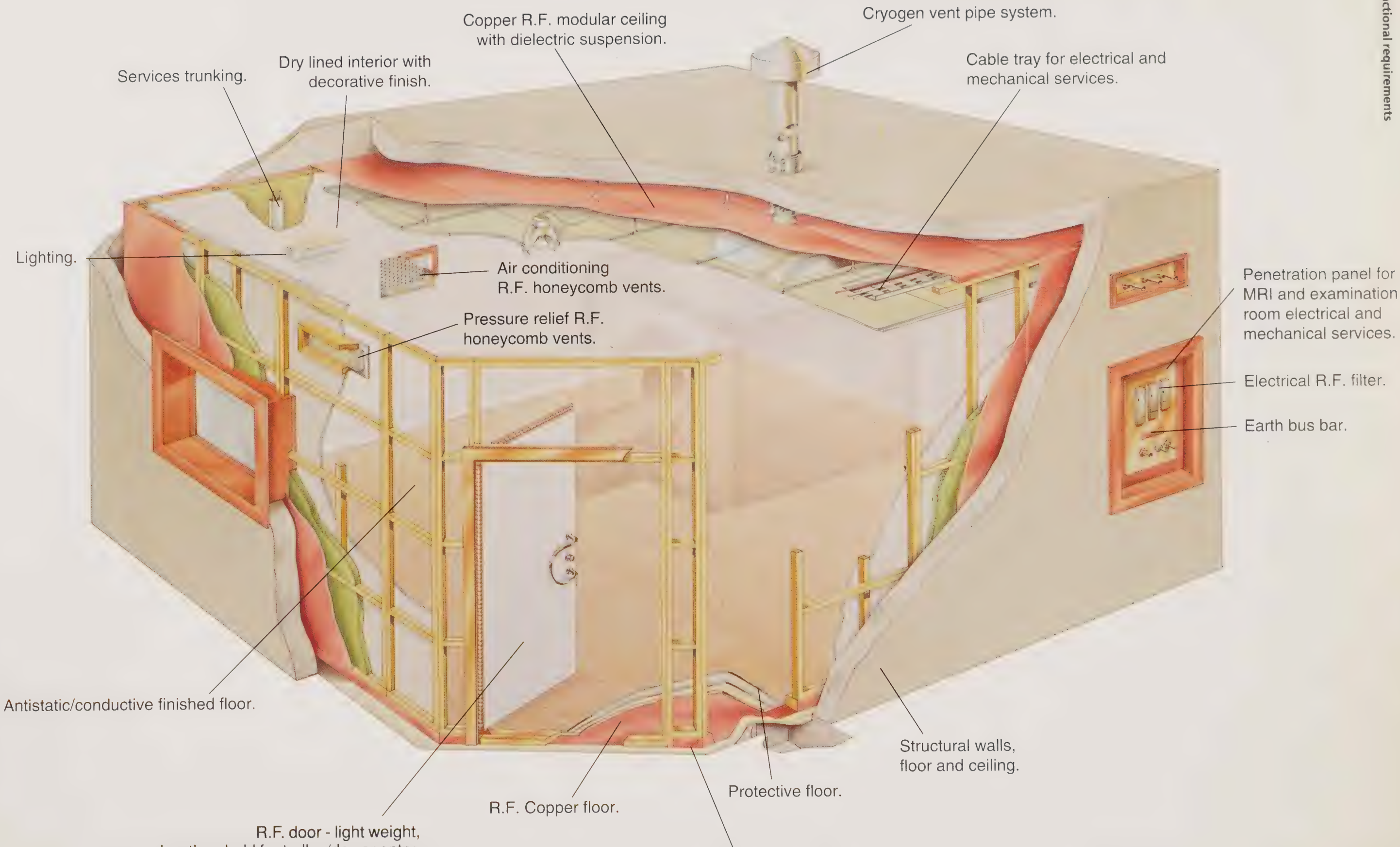
a. sedated;

b. anaesthetised;

c. in need of life support;

d. in need of physiological monitoring, for example ECG and pulse oximetry.

An anaesthetic machine, monitoring equipment, and/or other pieces of equipment, and an anaesthetist or other member of


Copper R.F. modular ceiling with dielectric suspension.
Cryogen vent pipe system.
Services trunking.
Dry lined interior with decorative finish.
Cable tray for electrical and mechanical services.
Lighting.
Air conditioning R.F. honeycomb vents.
Pressure relief R.F. honeycomb vents.
Penetration panel for MRI and examination room electrical and mechanical services.
Electrical R.F. filter.
Earth bus bar.
Antistatic/conductive finished floor.
R.F. door - light weight, low threshold for trolley/dewar entry,
R.F. Copper floor.
Protective floor.
Structural walls, floor and ceiling.

staff may need to remain in the scanner room with these patients. If possible, staff should not be subject to repeated exposure to MRI.

3.37 It may be necessary for a patient to be moved quickly from the scanner room – either for an emergency procedure, such as resuscitation, or because of an emergency with the equipment, for example, a quench (see paragraph 3.44(b)).

3.38 The scanner room should include conveniently sited electrical socket-outlets, wall-mounted piped oxygen, nitrous oxide, medical compressed air and medical vacuum outlets and anaesthetic gas scavenging (see paragraphs 2.52 and 2.56). MRI compatible anaesthetic and monitoring equipment should be stored in the general store in the MRI suite and brought to the scanner room as and when required.

3.39 Cupboards are required for the storage of a range of receiver coils, small items of equipment and miscellaneous disposable items. A pair of stacking chairs and an occasional table are the only other items of furniture which need to be provided.

3.40 Furniture and equipment which remains in, or is taken into, the scanner room must contain no ferromagnetic components.

3.41 The scanner room should be adjacent to the control room so that an observation window can be provided to enable MRI staff in the control room to maintain visual contact with a patient during the course of a scan. The scanner room should be close to the patient preparation rooms, patients' sub-waiting area, anaesthesia/recovery bay and technical equipment room and conveniently located in relation to the reporting room. (See Figure 4.)

3.42 The scanner room should be located to facilitate the special arrangements which must be made for the delivery of cryogens (liquid gases used to maintain magnet coils at superconducting temperatures) if the MRI scanner has a cryogenic magnet. Usually, cryogens are delivered in large, insulated containers called dewars. Dewars are available in non-magnetic stainless steel. They range in size from 600 to 1,200 mm in diameter and 1,500 to 1,800 mm in height, and weigh from 180 to 450 kg when full. The dewars need to be brought close to the magnet when the cryogens are being discharged.

3.43 The cryogen dewars will normally be unloaded from a truck and transported from the unloading point to the scanner. The route should have suitable openings and doors.

3.44 Siting the scanner room with an external wall will assist:

a. venting of cryogenic gas which "boils-off" routinely and during the filling process;

b. venting cryogenic gas released as a consequence of "quenching" of the magnet system. A quench is the sudden loss of superconductivity which causes rapid evaporation of cryogens. In the event of a quench, the patient should be removed immmediately as the oxygen level may be depleted and very cold gases may be present. A quench may be spontaneous or as a result of an inadequate level of cryogen;

c. replacement of the magnet, for which a removable panel should be provided.

3.45 Siting the scanner room at ground floor level will help:

a. minimise structural problems which may arise because of the weight of MRI equipment if the accommodation is provided at a higher level;

b. replacement of the magnet.

3.46 The design of the scanner room should facilitate the need to control access, as described in paragraphs 2.16 to 2.19. Design features may include provision of:

- access via the control room;
- a door control system;
- a door-open alarm.

3.47 Engineering features of the scanner room will include:

- cooling;
- oxygen level monitoring and alarm;
- intercom facilities between the patient and staff in the control room;
- RF-shielding and, if required, magnetic shielding.

Chapter 5 and the Activity Data A-Sheet provide further information. Consideration should be given to the provision of CCTV so that staff in the control room have a better view of the patient in the MRI scanner.

3.48 The specification for the ceiling, walls and floor of the scanner room will be partly determined by the type of magnet, and magnetic-field and RF-shielding selected. Special arrangements may need to be made at points where the surfaces are penetrated. If, for example, RF-shielded rooms are provided, they need to be fitted with RF-shielded doors and windows and access ports where services such as heating and ventilation ducts penetrate. A spare access port should be provided for possible future use at the time of construction as it is disproportionately expensive to add one later.

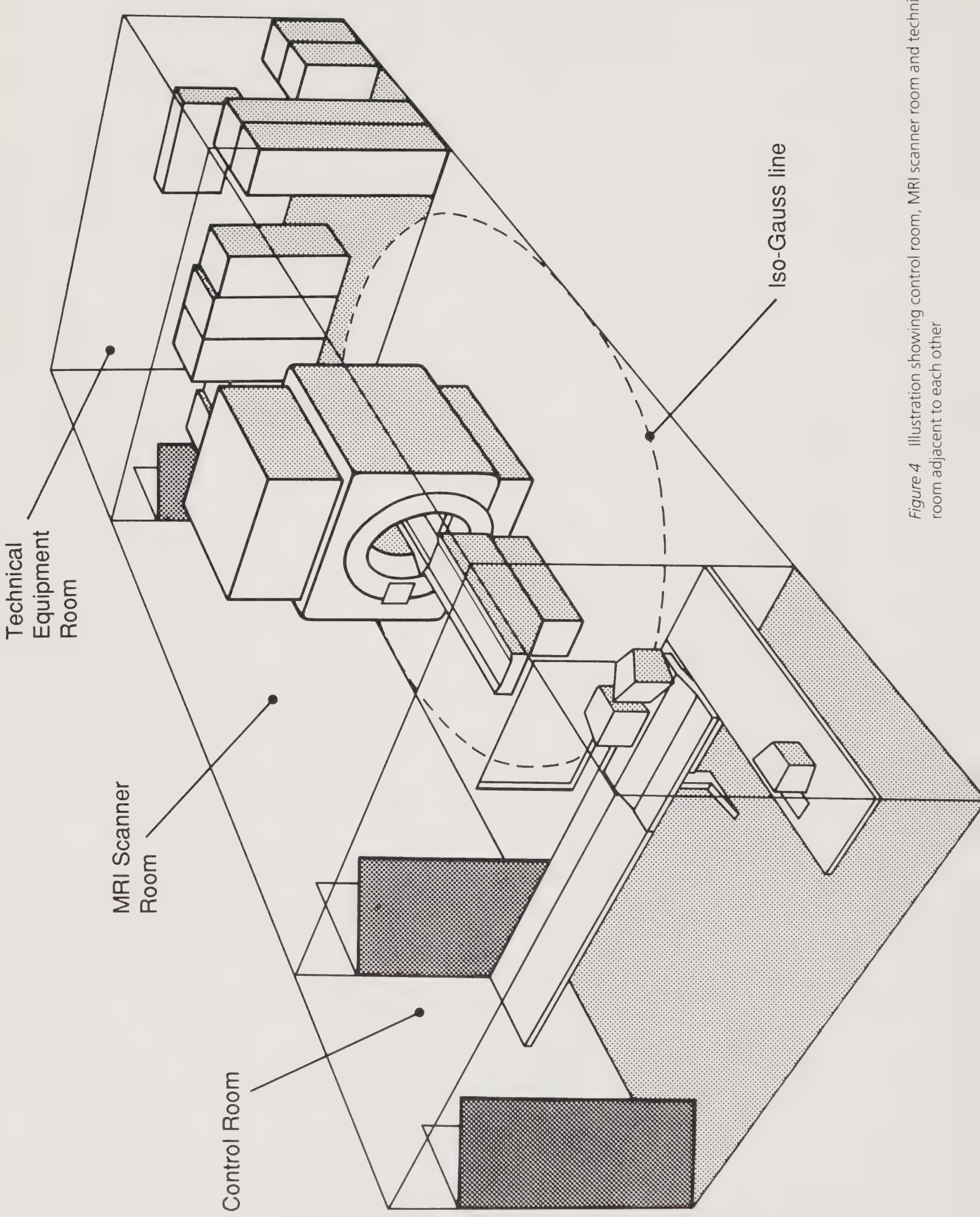


Figure 4 Illustration showing control room, MRI scanner room and technical equipment room adjacent to each other

3.49 Most of the information specified for ceilings in paragraphs 3.35 to 3.39 of HBN 6 does not apply in respect of the scanner room. The main requirements are:

a. to provide a ceiling height which will:
   (i) ensure that the surface of the floor above is outside the 5-Gauss line of the magnet;
   (ii) permit easy access for filling the magnet with cryogens;
   (iii) facilitate top venting of the magnet if necessary (see paragraph 3.44);
b. to consider the location of lighting fittings. Patients lying on the scanner couch should not look directly into bright lights.

3.50 Walls do not require a load-bearing capacity for equipment. The specification for the walls of a scanner room will depend on the type of magnetic-field and RF-shielding selected.

3.51 It is essential that great care is taken in the design of the floor. Issues which require consideration include:

- replacement of equipment should be possible with minimum disruption to the room and the suite;
- the weight of the equipment;
- the placement of structural steel relative to the magnet and screening;
- the floor surface should be at the same level as that of adjacent spaces;
- the floor finish. Provision of a carpet can help to create a "patient-friendly" environment. The need for hygiene and ease of maintenance should be recognised. HTM 61 – 'Flooring' should be consulted;
- the need for anti-static flooring (see paragraph 2.61).

Control room

3.52 MRI staff sit at the operating console in the control room from where they:

a. control the scanning process in the MRI scanner room. This includes monitoring the image of the scan on a VDT;
b. can communicate with the patient using an intercom;
c. may observe the patient through an observation window and/or by means of CCTV;
d. retrieve stored data and view the data on a VDT;
e. control the processing of hard copy of selected MR images.

The model of operating console will be project-specific.

3.53 A wall-mounted triple X-ray viewer should be provided for viewing films and, adjacent to the operating console, a worktop where staff can sit to read and write. Facilities are required for the storage of small items of equipment, reference books and stationery.

3.54 The control room should be adjacent to the MRI scanner room and located so that MRI staff seated at the operating console have the best view possible through an observation window of a patient in the bore of the magnet. It is helpful if the control room is adjacent to the reception/office and a hatch provided in an adjoining wall to facilitate direct communication between the two spaces.

3.55 One control room can serve an MRI and a CT scanner room. Separate operating consoles are required but other facilities can be shared.

3.56 Access to the MRI scanner room can be controlled and/or authorised from the control room.

MRI trolley bay

3.57 A special MRI trolley made from non-ferromagnetic material should be provided for moving non-ambulant patients into and out of the MRI scanner room. Arrangements may be made for patients to be transported to and from the MRI suite on the MRI trolley, or on a bed, ordinary trolley or wheelchair and transferred to the MRI trolley in the MRI suite.

3.58 An MRI trolley bay is required where the MRI trolley can be parked:

a. with a patient while waiting for an examination. Cubicle curtains are required to provide some degree of privacy. A staff emergency call point should be provided;
b. when not in use.

3.59 The MRI trolley bay should be located close to the entrance to the MRI scanner room.

Anaesthesia/recovery bay

3.60 A two-position anaesthesia/recovery bay is described in this HBN on the assumption that small numbers of patients who need to be anaesthetised will be interspersed with patients who do not need to be anaesthetised. If it is intended to group in one session all patients who need to be anaesthetised then project teams should examine patient flow and the adequacy of the two-position anaesthesia/recovery bay. Both positions should include facilities where the functions of induction of anaesthesia and post-anaesthesia recovery may take place. The induction area should be discrete from the recovery area.

3.61 The patient may arrive on a bed or a trolley. A child patient may be accompanied by a member of the paediatric nursing team and possibly a relative. The patient is anaesthetised on the bed or trolley on which they arrive, and is transferred to the MRI trolley to be moved to and from the MRI scanner room. The bed or trolley can remain parked in the anaesthesia/recovery bay until the patient is returned.

3.62 Facilities required include electrical socket-outlets, wall-mounted piped oxygen, nitrous oxide, medical compressed air and medical vacuum outlets, anaesthetic gas scavenging (see paragraph 5.16), storage units for drugs, sterile supplies and infusion fluids, and worktop for laying out instruments, etc and for writing notes. A lockable cupboard should be provided for the temporary storage of Controlled Drugs issued to an anaesthetist for a session. Some drugs may require refrigerated storage. A clinical handwash basin should be conveniently located for use by the anaesthetist. A sink-unit should be provided for washing instruments. Consideration should be given to the need for anti-static flooring (see paragraph 2.61).

3.63 It is preferable if each position is laid out in a manner similar to the anaesthesia rooms in the operating department in order that common working patterns can be followed.

3.64 Privacy and an environment with minimal disturbance are important. The bay should have walls on three sides and cubicle curtains to the opening and between each position. There should be adequate space around the patient on a bed or a trolley in each position for staff to move and work and for equipment to be moved and parked while in use.

3.65 The patient is moved to and from the MRI scanner room on the MRI trolley.

3.66 The patient is transferred to the bed or trolley for post-anaesthesia recovery and, following recovery, removal from the MRI suite to complete pre-discharge recovery elsewhere in the hospital.

3.67 The anaesthetist retains responsibility for the patient during the post-anaesthesia recovery period. The anaesthesia/recovery bay should be close to the MRI scanner room so that the anaesthetist can quickly and conveniently move between the two spaces.

3.68 The bay must be mechanically ventilated as the air will be polluted with exhaled anaesthetic gases (see paragraph 5.11). A staff emergency call point should be provided in case of, for example, cardiac arrest.

Resuscitation trolley bay

3.69 A resuscitation trolley bay should be provided in the MRI suite if it is impractical for the equipment in the resuscitation trolley bay serving the rest of the radiology department to be used for MRI patients.

3.70 A resuscitation trolley bay in an MRI suite should be located:

a. close to the MRI scanner room (but outside the 5 Gauss line of the MRI scanner) Ferromagnetic equipment must not be taken into the scanner room and a clear notice should be posted to indicate which, if any, resuscitation equipment may be taken into the room;

b. close to the anaesthesia/recovery bay;

c. with easy access to all spaces used by patients.

Technical equipment room

3.71 A room is required to accommodate technical equipment such as computers, equipment for generating the RF pulse and gradient amplifiers. The technical equipment room should be mechanically ventilated to deal with heat emission from the equipment. There should be space around the equipment to allow free circulation of air and easy access.

3.72 Upgrading of the MRI scanner is most likely to involve provision of additional technical equipment and this is reflected in the area provided. See Schedules of Accommodation, Chapter 6.

3.73 The technical equipment room should be located adjacent to the MRI scanner room.

Reporting room

3.74 The reporting room mainly accommodates the furniture and equipment required by radiologists for the preparation of reports on, and for studying, MRI scans.

3.75 The facilities should include:

a. a console linked to the MRI scanner where real-time or previous scans can be reported on and/or studied and from where hard copies can be ordered;

b. conventional office workstations (each with an L-shaped desk unit and VDT with keyboard), where a radiologist can sit to work and report on X-ray films displayed on a triple X-ray viewer mounted on the wall above the workstation;

c. a reporting bench where radiologists can sit to work and report on X-ray films displayed on an inset X-ray viewer or on a triple X-ray viewer mounted on the wall above the bench.

3.76 The reporting room can be used by staff for informal discussions and case conferences and as a reception and despatch point for X-ray films and records. A flame-resistant cupboard is required for the storage of laser discs, a bookcase with a cupboard and open shelves for reference books and journals, and a two-drawer filing cabinet for reports and correspondence, etc.

3.77 The VDTs should be linked to the departmental computer. The reporting room should be adjacent to the control room and the reception/office. Provision of hatches between the spaces will facilitate direct communication and transfer of documents.

Laser imaging room

3.78 A laser imaging room is required to accommodate project-specific laser imaging equipment for the production of hard copy of MRI images. The laser imaging room ideally should be adjacent to the MRI scanner room and technical equipment room and have good access from the control room.

3.79 It is not essential for the MRI suite to have a dedicated laser imaging room. It may be convenient to share a laser imaging room which serves another part of the radiology department or to share the laser imaging room in the MRI suite with another part of the radiology department.

Management office

3.80 A separate management office may be required as an administrative base for the manager of the MRI suite and where informal and confidential discussions can take place with patients, escorts, visitors and staff. The office should include an office workstation (with an L-shaped desk and VDT with keyboard), two easy chairs, and storage for books, journals and files.

3.81 The office should also provide an alternative location to the control room and reporting room for up to two other staff to view and report on X-rays. A worktop is required where staff can sit to work and use a double X-ray viewer mounted on the wall over the worktop and/or a VDT with keyboard.

3.82 The management office should have easy access to the control room, reception/office and reporting room.

General store

3.83 The general store provides accommodation for parking items of mobile equipment not in regular use, such as a syringe driver, anaesthetic equipment, infusion stands and an examination lamp, for storing bulk stocks of disposables, and for storing stationery.

3.84 Special cleaning equipment for use in controlled spaces may be stored in the general store. It is assumed that domestic staff who provide the cleaning service for the MRI suite will use the cleaners' room in the radiology department as their base.

4.0 General design considerations

4.1 Chapter 4 of HBN 6 contains guidance concerning aspects of function and design which are common to health buildings generally and which will need to be borne in mind when designing new buildings or upgrading existing premises. The guidance is relevant to the accommodation described in this Supplement.

5.0 Engineering services

Introduction

5.1 Most of the spaces required in the MRI suite of a radiology department in an acute general hospital are described in HBN 6. Therefore, HBN 6 (Chapter 5) should be consulted for the engineering design criteria, materials specifications and reference data which are generally applicable to the accommodation described in this Supplement.

5.2 The MRI scanner room, control room, and anaesthesia/recovery bay are, however, specific to the MRI suite. The additional engineering features and requirements associated with these spaces are described in the following paragraphs.

Radio-frequency shielding of services to MRI scanner room

5.3 All mechanical and electrical services entering the MRI scanner room must be routed through specially designed access ports so that the RF-shielding of this room is not compromised. The precise arrangements will be project specific and will need to be determined with the RF-shielding installation specialist. More information is contained in Appendix 1.

5.4 It is recommended that all engineering services are grouped, as far as practicable, prior to penetration of the RF-shielding barrier, so that an accessible services cupboard can be incorporated on either side of the shield to facilitate periodic maintenance inspections of the services and their RF access ports. It is also recommended that at least one "spare" access port be provided for possible future use since adding this later would be very expensive.

5.5 All engineering services and their supports within the MRI scanner room must be made of non-ferromagnetic material. It is suggested that ductwork be constructed of either aluminium or a plastic material and that pipework services be installed in copper.

5.6 Careful consideration should be given to the location and the direction of services routes within the MRI scanner room, as future access is likely to be restricted by the RF-shielding requirements.

MECHANICAL SERVICES

Heating

5.7 The general heating requirements for the MRI suite will be similar to those for the radiology department.

5.8 A conveniently sited, manual override time-restricted switch should be provided so that the local heating circuit can be restored promptly to its full operational state in MRI suites which might be used at night or on a weekend.

Ventilation

5.9 The main waiting and patients' sub-waiting areas and patient preparation rooms may require mechanical ventilation to suit the space location. The recommendations for ventilation of individual spaces are given on the Activity Space Data A-Sheets.

5.10 A separate dedicated conditioned air supply and extract system should be provided for the MRI scanner room and control room. This system should provide temperature and humidity control to meet the specific environmental needs of the scanner equipment. Air distribution and room temperature control limits should be designed to minimise discomfort to patients who may be confined within the scanner for prolonged diagnostic investigation.

5.11 The MRI scanner room and the control room should be provided with adjustable individual local temperature controls and status indication. These controls should be positioned so that staff can conveniently select the space condition within pre-set limits.

5.12 A separate open-vent duct will be required from the scanner equipment to external atmosphere for the safe discharge of cryogenic gases released as a consequence of "quenching" of the magnet system.

5.13 It is possible for helium and nitrogen gas to accumulate within the MRI scanner room if failure of the ventilation system is experienced. An oxygen monitoring device should be included in the MRI scanner room, with an alarm which sounds if the oxygen concentrations within this space fall below a specified level – typically 19%.

5.14 A mechanical ventilation rate of 15 AC per hour should be provided to the anaesthesia/recovery bay.

Piped medical gases

5.15 Piped medical gases outlets (oxygen, nitrous oxide, medical compressed air, medical vacuum and anaesthetic gases scavenging systems) should be provided in the anaesthesia/recovery bay and at a suitable wall position within the MRI scanner room, as indicated on the Activity Data A-Sheets and B-Sheets.

5.16 The emergency oxygen cylinder should be connected via an area valve service unit in the event of failure to the mains supply. This cylinder must be secured to ensure that it is not inadvertently taken into the controlled area.

ELECTRICAL SERVICES

Lighting

5.17 All light sources should have suitable colour rendering properties for clinical application within the scanner room, control room, anaesthesia/recovery bay, circulation areas and reporting room.

5.18 Due to the strong magnetic field within the scanner room, the use of an alternating current supply to coiled-coil filament lamps is likely to result in an extremely limited lamp-life caused by excessive vibration of the filaments.

5.19 The lighting within the MRI scanner room should be multi-switched to give variable levels of illumination for both patient comfort and routine servicing of the room and the equipment. It should be designed to achieve a restful, non-clinical ambience to help relax patients who are often apprehensive of confinement within the MRI scanner for prolonged diagnostic procedures. Particular attention should be paid to avoiding discomfort glare to a prone patient and a dark or dull appearance of ceiling and wall surfaces. Use of wall-mounted uplighters should be considered.

5.20 The general lighting within the control room, technical equipment room, laser imaging room, reception office, reporting room and management office should be in accordance with the guidance in the Lighting Guide LG3[(1)] for use with VDTs. The control room should also have variable lighting level control by means of multi-switching.

Power supply to MRI scanner

5.21 The electrical supply to the MRI scanner is usually critical with respect to external interference, supply fluctuations and impedance. If the supply cannot be guaranteed within acceptable limits, it may be necessary to consider the use of regulators, filters and isolating transformers.

5.22 The equipment manufacturer's advice should be sought during the design stage. If this is not practicable due to a later choice of manufacturer then details of all likely equipment choices will have to be considered and the most onerous engineering requirement may have to be satisfied.

5.23 Since the precise requirements will be both project- and equipment-specific, no provision for any of the above ancillary equipment has been included in the Departmental Cost Allowances.

5.24 Mains failure should be indicated at a suitable location to ensure awareness of the fault if the MRI suite is unoccupied.

Specialised wiring

5.25 Equipment and control trunking, conduits, etc should be provided between the technical equipment room, the control room and the MRI scanner room to accommodate the specialist contractor's wiring. All services entering the MRI scanner room must be taken through suitable RF-shielded access ports.

5.26 Control and data trunking, etc should be provided between the control room, the laser imaging room and the reporting room.

5.27 Data conduits, etc may also be required to connect the MRI suite with other departments of the hospital, depending on local operational policies for information technology.

Music

5.28 Outlets for background music should be provided in waiting and changing areas.

Fire safety

5.29 General advice on fire safety, including guidance on the additional fire precautions required in MRI suites, is contained in HTM 83.

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(1) 'Lighting guide: areas for visual display terminals', publication LG3, 1989, Chartered Institute of Building Services Engineers.

6.0 Cost information

Introduction

6.1 For all types of health buildings, it is important that building costs and revenue expenditure are kept as low as possible consistent with acceptable standards. Within this general context, HBNs provide a synopsis of accommodation for health buildings recommended for the provision of a given service.

Works cost

6.2 To prepare an estimate of the works cost, reference should be made to the Capricode Health Building Procedures Manual (Chapter 1, Stage 1, Annex 1.c.). The total cost allowance is derived by aggregating the cost of the functional units, the Essential Complementary Accommodation (ECA) and the Optional Accommodation and Services (OAS) as appropriate to the particular scheme.

6.3 The cost allowances cover the building and engineering requirements set out in this Supplement. In costing the MRI suite, it has been assumed that it will be located in the radiology department of a hospital where the common use of services will be available.

Functional unit

6.4 The functional unit for this Supplement is the MRI scanner.

6.5 The activity spaces and areas used for costing are listed in the Schedules of Accommodation at the end of this chapter.

Essential Complementary Accommodation (ECA)

6.6 This comprises activity spaces which are essential to the running of the MRI suite but which in certain circumstances may be available in a convenient location elsewhere. The ECA costed in this Supplement is listed in the Schedules of Accommodation at the end of this chapter.

Optional Accommodation and Services (OAS)

6.7 This Supplement, where appropriate, draws attention to alternative ways of providing services or facilities, including the likely cost implications. This information will enable project teams to select the solution which is most suitable to their needs. The OAS costed in this Supplement is listed in the Schedules of Accommodation at the end of this chapter.

Dimensions and areas

6.8 In determining spatial requirements, the essential factor is not the total area provided but the critical dimensions, that is, those dimensions critical to the efficient functioning of the activities which are to be carried out. To assist project teams in preparing detailed design solutions for the rooms and spaces, studies have been carried out to establish dimensional requirements in the form of critical dimensions. The results of these studies appear as ergonomic diagrams in HBN 40 – 'Common activity spaces'.

6.9 For development planning and at the earliest stage of a design it may be convenient for designers to have data available which will enable them to make an approximate assessment of the sizes involved. For this reason the areas prepared for the purpose of establishing the cost allowances are included at the end of this chapter.

6.10 It is emphasised that the areas published **do not** represent recommended sizes, nor are they to be regarded in any way as specific individual entitlements.

Circulation

6.11 Space for circulation, which includes allowances for planning provision, an engineering zone adjacent to the external walls, small vertical ducts and partitions, is shown in the Schedules of Accommodation and is included in the cost allowances.

Communications

6.12 Staircases, lifts and plantrooms are not included in the cost allowances. The MRI suite is deemed to share the radiology department's switchcupboard and enclosure for medical gas isolation.

Engineering services

6.13 The following engineering services as described in Chapter 5, and exemplified in the Activity Data, are included in the cost allowances. Primary engineering services are assumed to be conveniently available at the boundary of the adjoining accommodation.

a. **Mechanical services:**

(i) heating: low pressure hot water system;

(ii) ventilation: mechanical supply and extract to meet clinical and functional requirements – other areas will be mainly naturally ventilated;

(iii) provision of air cooling to the MRI scanner room and control room;

(iv) cold water service: centrally supplied to service points including drinking water and fire hose reels. Storage tanks excluded;

(v) hot water service: centrally supplied to service points. Storage excluded;

(vi) medical gas: piped supply of oxygen, nitrous oxide, vacuum and compressed air from the hospital central system. Anaesthetic gas scavenging system.

b. **Electrical services:**

(i) general lighting as required by tasks;

(ii) fluorescent, tungsten, safety and emergency luminaires as appropriate;

(iii) socket-outlets and other power outlets for fixed and portable equipment (but excluding power supplies to scanner, see paragraphs 5.21 – 5.23);

(iv) supplementary equipotential earth bonding connections and functional earthing;

(v) RF filters for electrical circuits to MRI scanner room;

(vi) standby and safety installation from the main hospital supplies;

(vii) patient/staff call system;

(viii) staff location – extension to the hospital system;

(ix) telephone internal cabling distribution and outlets. Handsets excluded;

(x) data transmission conduits only;

(xi) fire, medical gas and drug cupboard alarm systems; oxygen level monitor and alarm for MRI scanner room;

(xii) impulse clocks.

c. **Equipment (Group 1):**

triple film viewing screens in reporting room and control room.

Schedules of accommodation

Para no	Activity space	Space area sq m	Qty	Total area sq m
3.23	Patient preparation room	6.50	2.0	13.00
3.26	Patients' sub-waiting area	4.50	1.0	4.50
3.29	WC	2.00	1.0	2.00
3.29	Disabled WC	4.00	1.0	4.00
3.30	Locker bay	.50	1.0	.50
3.31	MRI scanner room	67.50	1.0	67.50
3.52	Control room	20.00	1.0	20.00
3.57	MRI trolley bay	7.00	1.0	7.00
3.60	Anaesthesia/recovery bay	18.00	1.0	18.00
3.71	Technical equipment room	21.50	1.0	21.50
3.83	General store	12.00	1.0	12.00
	Nett total			170.00
	Circulation			62.00
	Total			232.00
	Departmental area			230 sq m

Essential Complementary Accommodation

Para no	Activity space	Space area sq m	Circ'n etc sq m	Total area sq m
3.4	Reception/office	16.00	6.0	22.00
3.13	Main waiting area	18.00	7.0	25.00
3.16	Bed/trolley/wheelchair waiting area	7.00	3.0	10.00
3.19	Counselling room	9.00	3.0	12.00
3.69	Resuscitation trolley bay	2.50	1.0	3.50
3.74	Reporting room	15.00	5.0	20.00
3.78	Laser imaging room	8.00	3.0	11.00

Optional Accommodation and Services

Para no	Activity space	Space area sq m	Circ'n etc sq m	Total area sq m
3.80	Management office	12.00	4.0	16.00

7.0 Activity Data

Introduction

7.1 Chapter 7 of HBN 6 contains an outline description of the 'Activity Data' system and a list of A-Sheet numbers and titles applicable to HBN 6.

Activity Data applicable to this Supplement

7.2 Activity Data A-Sheets for spaces which are the subject of this Supplement (as included in the Schedules of Accommodation in Chapter 6) are listed below.

List of Activity Data A-Sheets

7.3 The Activity Data A-Sheets listed below may not carry a title identical to the activity space detailed in this Supplement. Use of the appropriate A-Sheet code number will result in the correct activity space being accessed.

Activity space	A-Sheet code no	Para no in HBN 6 Supp 1
1. Counselling room	D1701	3.19
2. Radiology: MRI scanner room	E0801	3.31
3. Radiology: MRI technical equipment	E0802	3.71
4. Radiology: MRI control room	E0804	3.52
5. Radiology: MRI reporting	E0805	3.74
6. Radiology: MRI laser imaging room	E0806	3.78
7. Radiology: MRI anaesthetic bay	E0807	3.60
8. Resuscitation trolley bay	G0104	3.69
9. Bed/trolley/wheelchair waiting area	G0202	3.16
10. Parking bay: MRI trolley, patient	G0204	3.57
11. Reception/office	J0605	3.4
12. Main waiting: MRI, up to 10 places	J1117	3.13
13. Sub-waiting: MRI, 4 persons radiology	J1212	3.26
14. Office: management, MRI	M0558	3.80
15. Locker bay: staff	V0628	3.30
16. Patient changing: 1 person with washing facilities	V0702	3.23
17. Washroom/WC: 1 person with mirror	V1005	3.29
18. Washroom/WC: 1 place, with calls with drinking water tap	V1104	3.29
19. Store: general, MRI	W0315	3.83

Appendix 1

Radio frequency shielding

1. Electrical services to the MRI scanner room require RF filtering. The filters are mounted on the RF shield and must be suitably grounded to it. The filter should be matched to the loading of the circuits in which they are installed. RF filters should be used for all electrical services, for example lighting, power, alarms and monitoring equipment. Further information is contained in HTM 2014 – 'Abatement of electrical interference (Design considerations)', 1993.

2. Mechanical services, liquids and gases, need to pass through filtering devices known as waveguides. In the case of air conditioning, the waveguides are packed together to form a honeycomb and the ducting is connected to either side of the honeycomb. In the case of liquids and gases, these need to be electrically isolated and advice should be sought from the RF-shielding installation specialists.

3. The open vent for cryogenic gases is generally made from stainless steel pipe to a bore size specified by the MRI equipment manufacturer. To enable the gas to pass through the RF shield a cryogen vent waveguide is provided. Both sides of the vent pipe are connected to the waveguide with connecting devices which have a dielectric barrier.

4. Special waveguides need to be used to "hard pipe" medical gases. Flexible pipes passed through open waveguides should not be used.

5. Fibreoptic cables can generally be passed through open waveguides provided that their sheathing is not electrically conductive.

6. The Faraday cage should be designed in consultation with the equipment manufacturer to ensure it contains the radio frequencies generated by the MRI scanner whilst also protecting the scanner from external radio signals in the frequency range at which it operates. It will therefore be a sheet metal enclosure, isolated from the building and earthed.

7. The most economic RF enclosure is a six-sided construction to the minimum size required by the MRI manufacturer. Most RF enclosures contain the MRI scanner although MRI systems are available which only require a half enclosure.

Appendix 2

Glossary

- **Cryogens**

Cold liquids, typically liquid helium and liquid nitrogen, used to maintain the magnet coils at superconducting temperatures.

- **Ferromagnetic**

Substance with large positive magnetic susceptibility that becomes magnetised within a magnetic field and remains magnetised after being removed from the field. Causes large magnetic field distortions, signal loss and can become a projectile when near a magnet.

- **Gauss (G)**

A unit of magnetic induction, where 1 Gauss = 0.1 mT. The earth's magnetic field strength is approximately 0.6 G.

- **Magnetic resonance (MR)**

The enhanced absorption of radio-frequency energy by nuclei or electrons in a static magnetic field when the energy is applied at the resonance frequency. In clinical applications, the term is assumed to represent interactions with nuclei, also called nuclear magnetic resonance (NMR). When applied to electrons, the method is called electron spin resonance (ESR) or electron paramagnetic resonance (EPR).

- **Magnetic shielding**

Method for containing the stray (fringe) magnetic field produced by an MR system.

- **Active magnetic shielding**

An extra set of current-carrying coils built into the magnet surround the main magnet coils and create an opposing magnetic field which reduces the external stray field significantly.

- **Passive magnetic shielding**

Iron plates are applied directly to the magnet (self-shielding) or are placed in strategic locations on the walls of the magnet enclosure (room-shielding). They form an integral part of the magnetic circuit.

- **Permanent magnet**

Magnet composed of large quantities of a permanent magnet material with high magnetic remanence and iron which is used to produce field strengths typically less than 0.3 Tesla. Typically have a vertical static field orientation and minimal stray magnetic fields.

- **Quench**

Sudden loss of superconductivity, typically causing rapid evaporation of cryogens. May be spontaneous or due to inadequate levels of liquid helium.

- **Radio-frequency (RF) pulse**

Oscillating magnetic field in the range 10–100 MHz, typically of relatively short duration, for example 1 to 10 msec, produced by an RF coil. In MR imaging, magnetic gradient fields, often pulsed, are applied in order to select individual slices of tissue.

- **Radio-frequency (RF) shielding**

A shield to protect MR signals and the receiver coil in an MRI scanner from contamination by extraneous signals which may be generated by a wide range of sources, including TV transmitters, commercial radio stations, two-way radios, paging systems and many types of electrical equipment, especially computers. Shielding also limits the transmission of the MR RF pulses into the environment.

RF-shielding is often provided by constructing an RF-shielded enclosure within the MRI scanner room. Various types of enclosure are available, including those made of copper or non-magnetic stainless steel.

- **Resistive magnet**

Magnet composed of current-carrying coils which requires continuous input of electrical current; used to produce field

strengths less than 0.4 Tesla. May have horizontal or vertical field orientation depending on magnet design.

- **Superconductive magnet**

Magnet consisting of superconducting windings which are contained within a sophisticated cryostat operating at liquid helium temperatures. A power supply is connected to the superconducting windings initially to ramp up the magnetic field to the operating level. The supply is then removed. Once ramped up to full field, it requires no additional input of electrical current. Typically used to produce field strength greater than 0.35 Tesla, these magnets have, in general, a horizontal static field orientation, and stray magnetic fields extend for large distances from the magnet unless magnetic shielding is used.

- **Tesla (T)**

Unit of magnetic induction equal to 10,000 Gauss.

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